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FUEL-TREATMENT EFFECTS ON SCENIC BEAUTY OF MIXED CONIFERS: FINAL REPORT

Terry C. Daniel

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Final Report

Cooperative Agreement No. 16-856-CA

Rocky Mountain Forest and Range Experiment Station
and
University of Arizona

April 1985

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Natural scenic beauty is recognized as an important resource, both in its own right and as an essential component of many outdoor recreation experiences. Legislation such as the Multiple-Use Sustained Yield Act of 1960 and the National Environmental Policy Act of 1969 early established that aesthetic qualities of the forest are to be carefully and explicitly considered in any forest management plan. This mandate has been reinforced and elaborated in more recent legislation, especially the Forest and Range Land Renewable Resources Planning Act of 1974 and the National Forest Management Act of 1976. Each of these acts requires that aesthetic resources be systematically assessed and that management impacts be explicitly and systematically considered in all forest planning activities. Individually and in the aggregate, these acts point to the need for the development of objective, quantitative methods for assessing and predicting changes in forest scenic beauty.

The Scenic Beauty Estimation Method (Daniel and Boster, 1976) was developed to meet the need for an objective, quantitative system of forest scenic quality assessment. The SBE method produces indices of scenic beauty for forest landscapes based on the perceptual judgements of panels of human observers; scenic beauty is defined and measured in terms of public consensus. This measurement system has proven a sensitive and

reliable scale for assessing scenic quality and has been shown to be valid and useful in a number of forest planning and management applications (e.g. Anderson, 1981; Benson & Ullrich, 1981; Daniel, et al., 1977; Schroeder and Daniel, 1980).

An important extension of SBE methodology is the development of scenic beauty prediction models (Arthur, 1977; Daniel and Schroeder, 1979; Schroeder and Daniel, 1981). Statistical models have been developed that successfully predict the perceived scenic beauty of Ponderosa pine forest sites based upon field inventories of overstory, understory, and ground cover variables. Further refinements and extensions of these models (e.g. Schroeder and Brown, 1983; Daniel et al. 1981) and integration of scenic models with models for stand growth and mortality, economic factors, and recreation use and quality (Daniel, et al. 1983) establish the utility of this approach for forest planning and management.

The purpose of the research reported here was to further extend the scenic beauty modeling efforts by developing preliminary models for mixed conifer forests. Modeling efforts to date have focused upon forest sites predominated by Ponderosa pine. Further, the models developed here address the short-term effects of forest harvest and thinning activities, where previous models tended to be restricted to sites where the effects of management activities were not so evident. This research also extended the biophysical inventories and scenic assessment of the Thomas Creek Experimental Watersheds reported by Anderson and Daniel (1977) and Vining et al. (1981).

The specific objectives of the study were to:

1. Complete a photographic inventory of the Thomas Creek Experimental Watersheds, continuing a photographic record begun in 1975.
2. Complete a biophysical inventory of overstory, understory, and ground cover features to be compared with pre-harvest inventories taken in 1978-79.
3. Provide a scenic beauty assessment of the Thomas Creek Experimental Watersheds and develop recent post-harvest scenic beauty prediction models.
4. For future research install permanent photographic monitoring stations at the Battle Flat Experimental Watershed. (See Appendix A)

METHOD

Site selection - The sites for the current research were the Thomas Creek Experimental Watersheds in the Apache-Sitgreaves National Forest in northern Arizona. These parallel watersheds are of mixed conifer vegetation type and have been permanently staked in a grid pattern with approximately .22 stakes per acre. The North watershed has remained unharvested since the original study begain in 1973. Timber harvest and fuel treatment in the South watershed began in 1978 and was completed in 1979 and 1980.

According to original timetables, harvest of the Thomas Creek South watershed was to have been completed in 1978 with post-harvest and recovery assessments done in 1979 and 1980, respectively. However, overstory harvest and fuel treatment

continued in 1980. In addition, harvest and fuel treatment occurred progressively over a two year period in various areas of the South watershed. Because of these factors, which produced an uneven treatment effect across the watershed as well as time, a sampling procedure was employed to select staked sample points in Thomas Creek South at which some treatment had occurred during 1978, 1979 or 1980. Points in matching areas (with regard to slope and aspect) were selected in the North watershed to represent preharvest conditions. A total of 87 sites were successfully sampled in the South Watershed and 63 sites were completed in the unharvested north watershed. Biophysical inventories and color-slide samples were taken at each point in 1981 and photo samples were repeated in 1982.

Biophysical Inventory - At each sample point a selected set of biophysical characteristics were measured using standard forest inventory procedures. Estimates were made of the number of stems in four-inch size classes for each tree species present using a variable-plot (10-factor prism) sampling scheme. Seedlings and saplings were inventories in fixed plots of 1/100th acre. Downed wood was measured using Brown's (1974) transect method (4 transects per site) and vegetative ground cover weight was estimated for four 9.6 square foot plots, with one randomly selected plot at each site clipped and weighed as a check on the accuracy of estimates. In addition, slope and aspect were recorded for each site. Schroeder and Daniel (1981) may be consulted for details of the inventory procedures and for a list

of the biophysical features that result.

Photographic Samples - Four color slide photographs were taken at each stake, or sample point, in both watersheds during September of 1981 and 1982. A random compass heading determined the direction of the first photograph, and the following three were taken at increments of 90, 180, and 270 degrees in a clockwise direction (refer to Anderson and Daniel, 1977, for more detailed information). A total of 600 color slides were collected (348 in the South Watershed and 252 in the North) in each year for presentation to observer panels.

The 600 slides for each year (1981 and 1982) were randomly divided into five groups of 120 slides and combined with a set of 25 common slides from the previous Thomas Creek study (Anderson and Daniel, 1977). Panels of subjects were shown either the 1981 or 1982 slide samples. University of Arizona student volunteers comprised the subject panels which ranged in size from 26 to 32. Subjects were asked to rate the landscapes represented in each slide on a one to ten scale of scenic quality. These ratings were subsequently analyzed with the Scenic Beauty Estimation (SBE) program (Daniel and Boster, 1976) which provided interval-scale standardized SBE's for each slide. In order to confirm the statistical equivalence of the ten subject groups (five for each year) SBE's for 25 common ("baseline") slides were compared. A Pearson product-moment correlation coefficient was calculated for each pair of subject groups. These coefficients ranged from .82 to.95 with a mean of .87, indicating a high

degree of agreement and establishing the relative equivalence of SBE's for all subject groups.

RESULTS AND DISCUSSION

Biophysical features and SBE values for each sample point were found by averaging the data from the separate sample plots or photographs taken at each point. For scenic assessment purposes, SBE values for individual points were compared separately or in aggregate with values for previous years (especially pre-harvest) and harvested and control watershed points were also compared. Scenic beauty models relating biophysical and SBE values at each site were developed following the methods described by Schroeder and Daniel (1981). Separate models were developed for the harvested South watershed (recent post-harvest models) and for the North (control) watershed.

Post-Harvest Scenic Recovery

Mean point SBE's were averaged to provide grand mean SBE's for each watershed in each year of the study. These data provide a comparison of the general effects of harvest and treatment in the South watershed with the baseline or control conditions in the North watershed. Also, comparisons with the earlier SBE assessments (in 1975, 1978, 1979 and 1980, see Table 1) provide a record of harvest effects and recovery.

Inspection of the historic SBE values of the North watershed revealed considerable annual variability, with particularly high values occurring in 1979, for example; review of photographs and

field notes from this watershed indicated that vegetation was especially lush following a wet summer season. Further, photography was enhanced in the 1979 sample by slightly overcast skies and generally moist conditions. This not only brought out colors in the landscape, but also decreased harsh visual contrasts that can be caused by bright sunlight. Analysis of variance (Vining, et al., 1981) indicated that annual differences in the North watershed (1975 to 1980) were statistically significant ($F(3/180) = 21.15$, $p < .05$). Because both watersheds were photographed at the same time it is logical to presume that the same visual enhancement occurred in the South watershed. Of course, seasonal and photographic effects would have been masked by the more marked effects of harvesting.

The North watershed was used as a control condition, with the focus of the study being upon differences between the SBE's obtained in the control and the treated watersheds over the various stages (years) of harvest and post-harvest recovery. These differences are graphed in Figure 1. The data graphed in Figure 1 show the expected drop in scenic beauty values for the South watershed, especially during 1979, the year of highest intensity of harvest operations. The beginning of a trend toward recovery is seen by 1980. An analysis of variance performed on these data by Vining, et al. (1981) indicated that the magnitude of the difference between SBE's in the two watesheds due to treatment main effect was statistically significant ($F(1/38) = 12.75$, $p < .05$). A significant treatment by year interaction term ($F(3/114) = 17.04$, $p < .05$) indicated that the marked divergence

of scenic values of the two watersheds over these years of the study was reliable. The addition of the samples for 1981 and 1982 shows that the harvested South watershed did recover its origina (1975) superiority in scenic quality.

Scenic Beauty Models - Following procedures reported by Schroeder and Daniel (1981), biophysical measures for each sample site in the North and South Thomas Creek watersheds were regressed on the obtained SBE values for those sites. A large number of possible models were developed and inspected, each involving somewhat different combinations of biophysical variables. Several models achieved very good statistical levels (adjusted R^2 near .50). The specific models presented in Tables 2 and 3 were selected on the basis of having achieved good statistical levels while including a series of variables that offered comparisons among the unharvested control (Table 2) and recent post-harvest (Table 3) models, as well as comparisons with previous Ponderosa pine models.

Comparing the pre-harvest and post-harvest models, several similarities are apparent. First, the presence of Ponderosa pine in any size class is a negative scenic beauty factor. Other tree species that entered the equations also effected scenic quality similarly in both pre- and post-harvest conditions. In general large Douglas firs added to scenic quality in both watersheds, while smaller Douglas firs detracted from scenic beauty. Of course interpretation of these patterns is complicated by the fact that a number of variables are in the equations and

especially later-to-enter variables may be "compensating" for earlier variables that share some variance. Aspen also entered the equations, with large size aspen having positive effects in both models, and seedlings and saplings having negative effects in the post-harvest model.

Herbaceous ground cover had very similar effects in both models, shrub weights being a negative factor and forb weights a positive factor. Downed wood effects were more complex. Both percent natural downed wood and the volume of 1/4" to 1" downed wood had positive effects on scenic beauty in the pre-harvest model. Larger sound downed wood and rotten downed wood tended to be associated with higher scenic values. Of course, the greatest volumes of downed wood in the unharvested (North) watershed were natural, as opposed to slash. The harvested watershed (South) had more slash, as is reflected by the fact that sound downed wood from 3" to 6" diameter had negative scenic effects in the post-harvest model. Rotten downed wood (12-20) entered as a positive variable, but had only a small effect on scenic values.

The most notable difference between the Thomas Creek mixed conifer models and previously reported Ponderosa pine models is that the number of pine trees, in all size classes, had negative effects on scenic beauty. Large pines have consistently been positive factors in the previous models. The effects of other tree species have generally been of lesser importance in the ponderosa pine models.

Ground cover effects also differed somewhat, with grasses playing no significant role in the mixed conifer models, being

replaced as a positive factor by forbs. This seems consistent with the fact that the mixed conifer stands were generally more closed canopied and wetter, so that forbs dominate the herbaceous ground cover. On the other hand, shrubs, generally a mildly negative to uninfluencial factor in ponderosa pine models, proved a strong negative factor in both of the Thomas Creek models. There are, of course, differences in shrub species associated with these two forest types. Those in Thomas Creek tend to be taller and more visually obstructing.

Downed wood has almost uniformly been found to be a negative factor in ponderosa pine models. Exceptions have generally been for very large diameters or for rotten downed wood. It is unclear why small downed wood (1/4" - 1") was a positive scenic factor in the pre-harvest model. Because such small pieces of downed wood are not usually even visible, it seems likely that some other associated variable (such as the presence of larger, twig-dropping, trees) is responsible for the positive relationship. Downed wood variables in the post-harvest model affected scenic beauty values in a way very similar to the earlier Ponderosa pine models; rotten downed wood was a weakly positive factor while 3 to 6 inch diameter volumes (mostly slash) were strongly negative.

CONCLUSION

The primary objective of research in the Thomas Creek watersheds, whether it is with regard to aesthetics, timber yield, wildlife, or water, is to provide relevant information for

the resource management process. In any land management situation options must be weighed. In order to optimize as many alternative resource uses as possible, some comensurability is necessary. The present study of aesthetic quality in the Thomas Creek watersheds has employed a control watershed as well as a longitudinal pre- and post-harvest design in order to provide a measure of the magnitude of scenic quality differences overtime. Such information could be employed in management decisions regarding harvest and fuel treatment in similar mixed conifer forest stands.

At Thomas Creek aesthetic values must be weighed with consideration of timber yield, fire hazard, management costs and a number of other economic and environmental factors. The present study indicates that timber harvest initially produced lower scenic values in the South watershed in comparison with the North. However, this and previous research has shown that, over time, timber harvest may actually improve scenic values. Anderson and Daniel (1977) found that extent of view was a strong predictor of scenic beauty. Because timber harvest or thinning tends to open a forest and increases the extent of view post-harvest improvement of scenic values may be expected. In the 1981 and 1982 assessments scenic beauty values in the South watershed surpassed those in the North. Indications of continuing scenic recovery suggest that post-harvest conditions may exceed pre-harvest in the South watershed.

While timber harvest may eventually improve scenic values, there is strong evidence that the short range values will be low,

primarily due to the presence of slash, or downed wood (Anderson and Daniel, 1977; Arthur, 1977: Benson, 1974; Daniel and Boster, 1976.) The current research provides further evidence that harvest by-products contribute to lower scenic values. Improvement in short range scenic values may be expected with intensive slash treatment. While such intensive treatment may be costly, it should be noted that effective slash disposal could pay multiple benefits, providing greater utilization and increased fire protection, as well as improved scenic values.

The Thomas Creek scenic beauty models must be viewed as preliminary efforts, due to the small and restricted sample of forest sites on which they are based. Nevertheless, several conclusions seemed merited based on comparisons between pre- and post-harvest models and previously reported ponderosa pine models. Consistent findings are that greater numbers of large trees and lesser numbers of small and medium sized trees produce a more scenically attractive forest. Of course, in Thomas Creek it is large Douglas fir and to some extent aspen, (but not Ponderosa pines) that are important. Also, downed wood that is produced by harvest is repeatedly found to be a negative aesthetic factor. Lush, but low ground covers--grass in ponderosa pine forests and forbs in mixed conifers--are important positive factors in scenic quality. Shrubs, especially when thick and high enough to be visually obstructing, are moderate to strong negative factors.

The general conclusions indicated by the scenic beauty models are not surprising--people prefer open, park like forest

landscapes. However, it is important to note that the quantitative precision of the scenic beauty models enables evaluation of trade-offs between scenic and other consequences of forest management that have not here-to-fore been possible. With these models, for example, the scenic consequences of harvesting or leaving a given number of large grees can be relatively precisely determined. Costs of slash disposal can be systematically assessed in comparison to specific gains in publically perceived scenic beauty. Further, when linked to models of forest growth and change, scenic beauty models enable a reasonable forecast of post-management declines and recovery of scenic values. Such capabilities are essential to the systematic integration of scenic beauty concerns within the large complex of forest management and planning activities; an integration mandated by congressional acts and long sought by responsible public land managers.

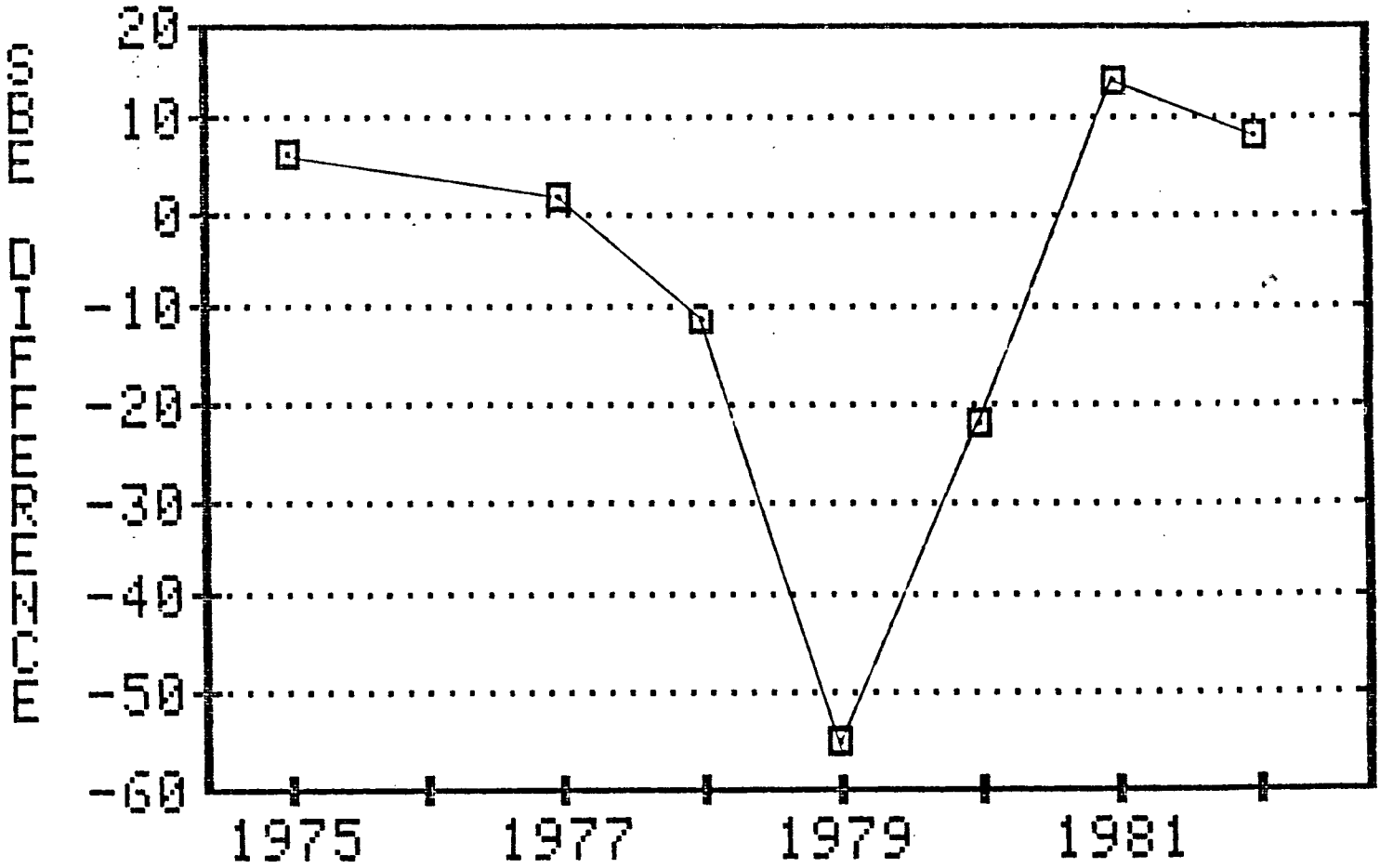

FIG. 1. SEVEN YEAR HISTORY OF SBE TREATMENT MEANS MINUS CONTROL MEANS

TABLE 1.

Mean values for Control (North) and Treated (South) Thomas Creek watersheds.

	1975	1977	1978	1979	1980	1981	1982
CONTROL (N)	-7.88	-27.85	7.06	37.78	12.07	-11.18	-18.10
TREATED (S)	-1.90	-25.79	-4.07	-17.25	-9.68	2.96	-9.63

TABLE 2

Model for Untreated Watershed

Variable	Mean	SD	b	beta	R
Percent natural downed wood 0-3" diam.	8.84	0.53	8.768	.201	.27
Aspen 12 + dbh	3.12	9.06	.620	.243*	.33
Douglas fir 0-4.5' ht.	2228.57	2237.25	-.003	-.297*	.42
Downed Wood 1/4-1" diam.	57.71	39.34	.176	.299*	.46
Ponderosa pine 9-12" dbh	3.86	9.59	-.776	-.322**	.51
Shrubs (pounds per acre)	18.49	9.70	-.877	-.368**	.55
Douglas fir 24-28" dbh	1.57	2.43	2.925	.308*	.59
Sound natural downed wood 9-12" diam	52.48	145.71	-.052	0.327**	.62
Sound natural downed wood 12-20" diam	173.36	323.80	.024	.330**	.67
Rotten natural downed 2ood 6-9" diam	101.78	134.07	.040	.235*	.69
Douglas fir 16-20" dbh	8.37	8.93	-.671	-.259*	.72
Forbs (pounds per acre)	66.47	70.48	.077	.235*	.74
Constant			-81.655		

Adjusted R^2 = .45

* $p < .05$
** $p < .005$

TABLE 3

Model for treated Watershed (N = 87)

Variable	Mean	SD	b	beta	R
Aspen 0-4.5' ht.	1434.48	2542.19	-.003	-.272**	.30
Rotten downed wood 12-20" diam.	330.69	494.27	.006	.129	.38
Sound downed wood 3-6" diam.	261.22	199.20	-.033	-.278**	.44
Ponderosa pine seedlings 0-1" ht.	285.06	681.23	-.005	-.130	.49
Ponderosa pine 24-28" dbh	0.58	1.37	-1.92	-.11	.52
Douglas fir 24" + dbh	2.04	2.58	2.480	.272*	.54
Dougls fir 20-24" dbh	2.53	3.86	-1.783	-.293**	.57
Aspen 20-24" dbh	0.09	0.60	8.817	.226*	.61
Douglas fir 0-5" dbh	1110.34	1532.14	.004	.244*	.63
Douglas fir 5-9" dbh	56.90	79.46	-.059	-.189*	.65
Shrubs (pounds per acre)	19.76	16.93	-.409	-.295**	.67
Ponderosa pine 5-9" dbh	8.21	34.20	-.140	-.204*	.68
Forbs (pounds per acre)	77.33	66.48	.083	.234*	.70
Douglas fir 16-20" dbh	5.72	8.49	.427	.154	.72
Constant			1.184		

Adjusted R^2 = .42

* p <.05
** p <.005

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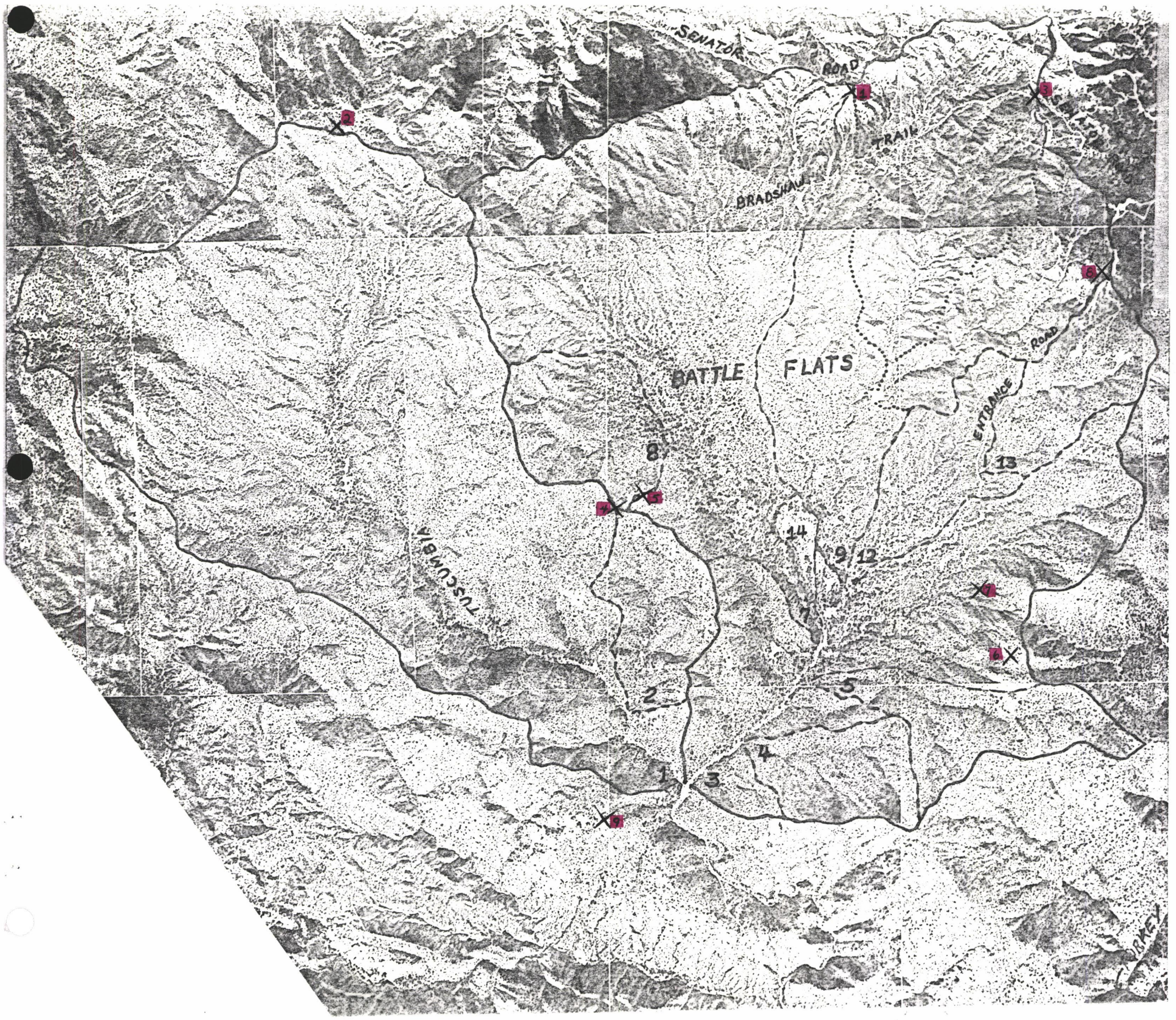
Appendix A: Photographic Monitoring Stations for Battle Flat Experimental Watershed, Arizona

As a result of several field visits to the Battle Flat and Tuscumbia Watersheds, photographic monitoring stations were selected according to the following criteria:

1) Each site should offer extensive views of the targeted watershed (<u>either</u> Battle Flat or Tuscumbia, but not both) with relatively little coverage of areas outside the watershed.
2) Each site should offer a panorama, allowing near 180° views of the target watershed.
3) Stations should provide views of the watersheds from several different perspectives, including views from higher elevations looking down over the watershed, lower elevation perspectives up the watershed, and views across the watershed at several different elevations.

A total of 9 stations were located, 6 for Battle Flat and 3 for Tuscumbia. Each station was permanently marked on the ground, indicated on aereal photographs of the area, and mapped. The attached map shows the location of each station and the approximate angle of view captured by the multiple photos taken at each station.

To date photographic (33mm color slides, Kodachrome 64) samples have been collected in the summers of 1982, 1983, and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FLATS
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1984. These photos have been inspected, labeled and filed in the Environment Perception Laboratory, Psychology Building, University of Arizona.